PATENT SPECIFICATION

(11) 1 412 298

(21) Application No. 41050/72 (22) Filed 5 Sept. 1972

(23) Complete Specification filed 29 Nov. 1973

(44) Complete Specification published 5 Nov. 1975

(51) INT CL² H04M 1/30

(52) Index at acceptance

G4H 1A 1C 2A 5X 6B 6D 6E 7A3 7B 7X 8C 8E KB

H1N 441 443 45X 626 637 649 652 654 700 704

(72) Inventor KEITH ANTHONY THOMAS KNOX

1 412 298

(19)

(54) ELECTRICAL SIGNAL INITIATING KEYBOARDS

(71) We, THE POST OFFICE, a British body corporate established by Statute, of 23 Howland Street, London, W1P 6HQ, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrical signal initiating keyboards and more particularly, but not exclusively, to telephone instrument push-button keyboards.

Telephone instruments currently in use employ the familiar dial unit as a means for generating a train of electrical impulses representing the number of the subscriber being called. The dial unit has proved generally satisfactory and relatively cheap for this purpose, but being purely mechanical in operation can suffer from wear after long use. The operation of the dial can be somewhat tiring to the caller when many calls are to be made, particularly as trunk calls generally require ten dial movements per call.

Electrical signal initiating keyboards in the form of push-button keyboards are used in telephone instruments as an alternative to the dial unit for initiating a destination coded signal. The signal produced by a push-button keyboard is not necessarily transmitted as a train of electrical impulses as for the dial unit. Prior art push-button keyboards have proved preferable to the dial unit so far as ease of use by the caller is concerned but have nevertheless proved unsatisfactory in other respects. For example, push-button keyboards using moving electrical contacts have been found to incur a fault liability, particularly when operated in low impedance circuits. Push-button keyboards utilising a discrete electronic device for each button (for example, piezo-electric crystals or Hall effect devices) have been proposed but are generally more expensive than the familiar dial unit.

It is an object of the invention to provide an improved electrical signal initiating keyboard.

The present invention provides an electrical signal initiating keyboard including:

a number of motion transmitting elements;

a layer of resiliently deformable insulating foam material having at one face thereof a plurality of electrically conductive tracks defined by conductive particles and separated by non-conductive areas of the foam; and

a plurality of terminals connected to associated ones of the tracks the arrangement being such that each motion transmitting element is operable to deform a respective area of the foam material to thereby change the resistance between terminals associated with that particular area.

Preferably, the insulating foam material is a polyether polyurethane foam with conductive tracks formed by graphite particles therein.

The motion transmitting elements can be push-buttons manually operable to compress the foam material against a rigid plate.

By way of example only, two illustrative embodiments of the invention will now be described with reference to the accompanying drawings, of which:—

Figure 1 shows a plan view of a variable resistance element employed in the embodiments;

Figure 2 shows an "exploded" view, partly in section, of a first electrical signal initiating keyboard embodying the invention;

Figure 3 shows a cross-sectional view through part of the keyboard of Figure 2;

Figure 4 shows an "exploded" view, partly in section, of a second electrical signal initiating keyboard embodying the invention;

Figure 5 shows a cross-sectional view through part of the keyboard of Figure 4;

Figure 6 illustrates the electrical operation of the keyboards;

Figure 7 shows an approximate equivalent circuit for the keyboards;

Figure 8 shows one way of combining the outputs of the keyboards; and

Figures 9A and 9B show how resistance characteristics can be modified by the use of additives.

It should be noted that in the interests of clarity the drawings have been simplified and relative dimensions exaggerated in places.

Referring to Figure 1, a resiliently deformable variable resistance element employed in both the embodiments comprises a piece of insulating foam 1 with conductive tracks 2 applied to one surface thereof. The foam 1 is a polyether polyurethane foam approximately 3 inches by 4 inches and 0.4 inches thick. The foam has a fine cell structure, an example of a suitable foam being "Kayfoam Polyether E35" (density 22 kg/M^3) manufactured by Kay-Metzeler Ltd., of Cheshire. The conductive tracks 2 are applied in the pattern shown by screen printing or by use of a contoured roller and comprise graphite particles. A suitable material for forming the conductive tracks 2 is that known by the registered Trade Mark "AQUADAG" and of the grade having an 18% solids content. To ensure that the graphite particles bond firmly to the foam and to improve the rheological properties of the AQUADAG during application certain additives are preferably mixed with the AQUADAG before its application. For example, up to 5% of 50—60% strength vinyl acetate-vinyl versatate copolymer (such as that sold by Vinyl Products under the trade name "Vinapol 1070") can be added to improve bonding. Sodium alginate is a suitable material for thickening the AQUADAG to modify its rheological properties so that excessive lateral diffusion does not occur during the printing process. The use of sodium alginate can also decrease the contact resistance of the conductive tracks 2 and the use of 1 part of a 2% aqueous sodium alginate solution (preserved with formaldehyde) to 3 parts AQUADAG was found successful in this respect (this concentration represented approximately 0.5% sodium alginate dry weight). It was also found that the property of sodium alginate to decrease contact resistance could itself be modified by use of a gelling agent. For example, the introduction of Ca^{++} ions by the use of $CaCl_2$ and compensated by the addition of $EDTANa_2$ (a sequestering agent) produced a high contact resistance at low pressure and thereby increased the range of resistance variation since the contact resistance at large pressure was substantially unchanged. Alternative materials for modifying the contact resistance properties of the conductive tracks 2 are dimethyl sulphoxide (DMSO) at about 5—15%, cetrimide at about 1%, benzalkonium chloride, cetyl trimethyl ammonium bromide and a liquid anionic detergent based on mixed sodium alkyl sulphates of long chain alcohols such as TEEPOL (RTM).

Figure 9A comprises a graph showing the effect of various additives on surface resistance and Figure 9B is a similar graph relating to bulk resistance. Each graph shows eleven curves, a to g inclusive, and the various additives represented by these curves are set out below: ·

Curve a — Vinapol vinyl acetate-versatate copolymer in the concentration given above
Curve b — as for curve a but with the additive of sodium alginate in the concentration given above
Curve c — as for curve b but with the addition of a trace of benzalkonium chloride
Curve d — as for curve b but with the addition of cetyl trimethyl ammonium bromide
Curve e — as for curve b but with the addition of TEEPOL
Curve f — as for curve a but with the addition of a trace of benzalkonium chloride
Curve g — as for curve a but with the addition of 15% DMSO
Curve h — as for curve a but with the addition of 5% DMSO
Curve i — as for curve a but with the addition of 5% DMSO and of cetyl trimethyl ammonium bromide
Curve j — 5% DMSO
Curve g — 15% DMSO

There is no resistance value shown for zero applied force (light contact) for curves, b, c, d, e, f, and g of Figure 9A as a spacer was used to ensure very high resistance at zero applied force.

The following points are notable:

(i) Curve a shows only a small change in bulk resistance in comparison with the change in surface resistance with applied force.

(ii) Curve b illustrates that resistance is increased by the use of sodium alginate.

(iii) Curves c and f show that the effect of benzalkonium chloride is to bring about an increase in the change of resistance with applied force, particularly so for bulk resistance.

(iv) Curve e shows that TEEPOL exerts a similar effect to benzalkonium chloride.

(v) Curve h shows an increased resistance at zero applied force but without commensurate increase in resistance when force is applied, there is an increased range of bulk resistance change.

Referring now to Figures 2 and 3, a keyboard for use in a telephone instrument comprises twelve depressible keys or buttons 3 arranged in a matrix of 4 rows of 3 keys. Each key is suitably inscribed with an alphanumeric symbol or legend (not shown). Ten of the keys are used to signal the digits 0 to 9 for a telephone number code and the remaining two keys are used for auxiliary purposes, for example, "special facilities" and "service facilities".

The keys 3 are located on an upper plate 4 which is a onepiece moulding of a rigid plastics materials of a generally flat form. Each key 3 respectively comprises a peg 5 projecting through a hole in the plate 4 with a flange portion 6 at its lower end. The other end of the peg 5 is received in a cap 8, the cap either being a tight push fit on the peg or being retained by adhesive. Each peg 5 is a sliding fit in its respective hole and, if desired, a helical compression spring 9 acting against the top of the plate 4 and the underside of the cap 8 and positioned about the peg can be included in the key assembly. Such springs are not strictly necessary since their function (to bias the keys in an up position) can be accomplished by the resiliency of the foam 1 without further aid.

A set of cross-members, such as reference 10, and a peripheral member 11 are provided to ensure the rigidity of the plate 4.

Positioned beneath the plate 4 is the insulating foam 1 with its conductive tracks 2 positioned downwardly. Connections (not shown in Figure 2) are made to the conductive tracks by stapling, eyeletting or by use of a conductive cement.

An insulating spacer 12 is positioned beneath the foam 1 and comprises a piece of polythene film in the range 0.006 to 0.020 inches thick with twelve holes 13 each underlying a respective key 3. Foam material can be used as an alternative to film and other types of polymer can be used. As another alternative, paper can be used. It is, however, preferred that the thickness of the spacer 12 should be greater than 0.002 inches and less than 0.150 inches.

A layer of conducting material 14 to which a connection is made (not shown in Figure 2) is positioned beneath the spacer 12. The conducting material 14 can be carbon-loaded paper, metallised polymer foil or, less desirably, tin-oxide coated glass. If the conducting material comprises a conducting layer on an insulating layer, rather than being a homogeneous conductor, it is placed conductive side up. A pick-off connection of the conducting material 14 is made by stapling, eyeletting or the use of a conductive cement.

A base-plate 15 of rigid plastics material is positioned beneath the material 14. Assembly of the various parts of the keyboard can conveniently be achieved by use of an insulating adhesive.

The electrical operation of the keyboard will be discussed later.

Referring now to Figures 4 and 5, a second form of Keyboard for use in a telephone instrument is illustrated. The similarity of this second keyboard to the first keyboard is immediately apparent and therefore description will be confined to pointing out the difference between the two keyboards.

In the second keyboard, the keys 3 form an integral part of the plate 4 which is of a resilient plastics material. The cross-members 10 and peripheral member 11 impart stiffness to the plate 4 and divide it into twelve areas, each area containing a key 3. It is thus possible to depress any one of the keys against the resiliency of the plate 4 with negligible movement of the other keys.

The conductive layer 14 (conducting side down if a conductor/insulator laminate is used) is positioned beneath the plate 4 and the remaining components are positioned in the order, spacer 12 foam material 1 (conductive tracks uppermost) and plate 15. In this embodiment the layer 14 has to resist distortion due to cyclic distortion and is therefore preferably constructed from a polymeric material.

The two embodiments differ only in mechanical operation, their electrical operation is essentially the same. Referring to Figure 6, it will be seen that a respective terminal is connected to each conductive track 2 and these terminals are referenced A, B, C etc. up to O. Each conductive track makes contact when an associated key is depressed with conductive material 14 through a hole 13 and this feature is illustrated by the hatched circles in Figure 6. The conductive tracks connected to terminals A, B, C, D, F, G, H, I, L, M, N, O each overlie one hole 13 whereas the conductive tracks connected to terminals E, J, K, each overlie four holes 13. Each of the hatched circles in Figure 6 corresponds, of course, to a respective key and this feature is illustrated by marking the circles with respective symbols 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, X and Y. Depression of the key bearing the number 1, for example, cause compression of the part of the foam on which the conductive tracks connected to terminals D and E are positioned. Compression of the foam by an overlying key results in the conductive tracks underlying the key being brought into contact with the conductive layer 14. The resistance on contact decreases with increased pressure on the key and in an experimental keyboard was found to be 100 k for 40 Z, 50 k for 80 Z and 15 k for 16 OZ. The spacer ensures infinite resistance when the key is underpressed. Thus, a resistance drop is observed between terminal D and layer 14, and between terminal E and layer 14 when the key bearing the number '1' is depressed.

Figure 7 shows an approximate equivalent circuit for the keyboards. Terminal E, for example, is shown connected to layer 14 by four variable resistors in parallel, each resistor corresponding to one of the four possible connections of the track to layer 14 through holes 13.

The resistance change with increased pressure is believed to be due almost entirely to changes in surface contact resistance and it is believed that bulk resistance changes are insignificant so far as the overall effect is concerned.

Figure 8 shows one way of connecting the keyboards to provide a "2 out of 7" coded indication of which key is depressed. Terminals A, G, O are commonly connected to a line reference α, similarly B, F, N; C, I, M; and D, H, L are connected to β, γ and δ respectively.

Terminals E, J and K respectively connected to lines ϵ, ζ and η. It can easily be seen that if, for example, the key bearing the number '3' is depressed the resistance between lines η (connected to K) and δ (connected to L) and conductive layer 14 drops. Thus, if different electrical signals are applied to the lines α, β, γ, δ, ϵ, ζ and η two of these signals will be communicated to the conductive layer 14. The table below sets out the operation of the keyboard connected as shown in Figure 8.

Key	Resistance change
1	$\delta\ \epsilon$
2	$\delta\ \zeta$
3	$\delta\ \eta$
4	$\gamma\ \epsilon$
5	$\gamma\ \zeta$
6	$\gamma\ \eta$
7	$\beta\ \epsilon$
8	$\beta\ \zeta$
9	$\beta\ \eta$
0	$\alpha\ \zeta$
X	$\alpha\ \epsilon$
Y	$\alpha\ \eta$

The keyboards are, of course, connected to suitable interface equipment for use in generating dialling code pulses or frequencies.

It will be appreciated that many modifications to the described embodiments are possible. For example, the spacer plate 12 can be omitted so that there is finite resistance associated with unactuated keys. The use of the additives mentioned earlier helps to obtain a high range of values between 'off' resistance (lightly contacting) and 'on' resistance (14 contacting under finger pressure).

If desired, each key can be arranged to act against a metal spring so that a snap-action and an audible "click" is obtained on depressing the key.

The conductive layer 14 can be in the form of an interconnected metallic pattern corresponding to the holes 13 on an insulating layer.

It is a notable feature of the described embodiments that expensive materials such as gold are not required and that the keyboards have a much smaller fault liability than the prior art moving contact type of keyboard.

WHAT WE CLAIM IS:—

1. An electrical signal initiating keyboard including:

a number of motion transmitting elements;

a layer of resiliently deformable insulating foam material having at one face thereof a plurality of electrically conductive tracks defined by conductive particles and separated by non-conductive areas of the foam; and

a plurality of terminals connected to associated ones of the tracks the arrangement being such that each motion transmitting element is operable to deform a respective area of the foam material to thereby change the resistance between terminals associated with that particular area.

2. A keyboard as claimed in claim 1 wherein the motion transmitting elements are push-buttons manually operable to compress the foam material against a rigid plate.

3. A keyboard as claimed in claim 2 wherein the push buttons form an integral part of a plate of resilient plastics materials.

4. A keyboard as claimed in any preceding claim including means to provide a snap-action for the motion transmitting elements.

5. A keyboard as claimed in any preceding claim wherein the foam comprises polyether polyurethane foam.

6. A keyboard as claimed in any preceding claim wherein the conductive particles comprise graphite particles.

7. A keyboard as claimed in claim 6 wherein the conductive particles comprise graphite particles in association with a resistance-modifying additive.

8. A keyboard as claimed in claim 7 wherein the additive is sodium alginate, or dimethyl sulphoxide, or cetrimide, or vinyl acetate-versatate copolymer, or benzalkonium chloride, or cetyl trimethyl ammonium bromide, or a liquid anionic detergent based on mixed sodium alkyl sulphates of long chain alcohols.

9. A keyboard as claimed in any preceding claim wherein a layer of electrical insulating material having a plurality of apertures therein is provided between the conductive tracks and a layer of electrically conducting material and wherein the motion transmitting elements are operative to press the conductive tracks and conductive layer into contact through the said apertures.

10. A keyboard as claimed in claim 9 wherein the motion transmitting elements act against the foam material.

11. A keyboard as claimed in claim 9 wherein the motion transmitting elements act

against the conductive layer, the said layer being resilient.

12. An electrical signal initiating keyboard substantially as herein described with reference to and as illustrated by Figures 1, 2, 3 and 6 or by Figures 1, 4, 5 and 6 of the accompanying drawings.

13. A telephone instrument including a keyboard as claimed in any preceding claim.

ABEL & IMRAY,
Chartered Patent Agents,
Northumberland House,
303—306 High Holborn,
London, WC1V 7LH.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1975.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

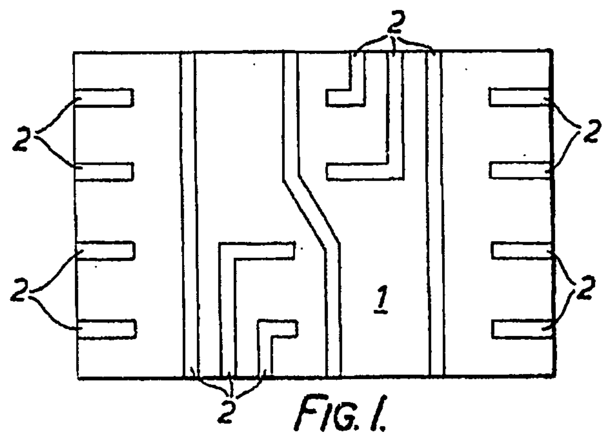

FIG. 1.

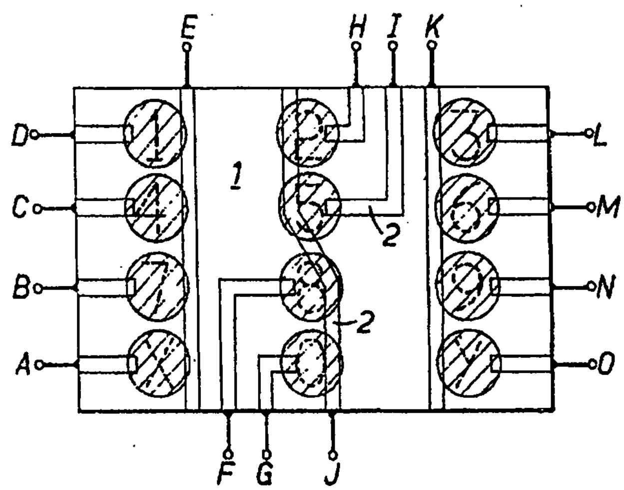

FIG. 6.

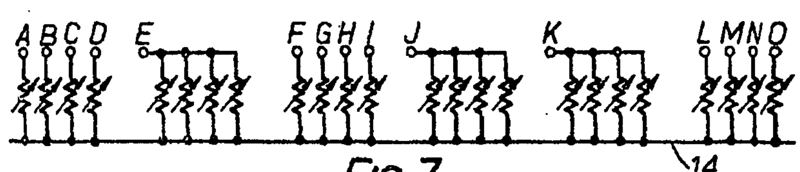

FIG. 7.

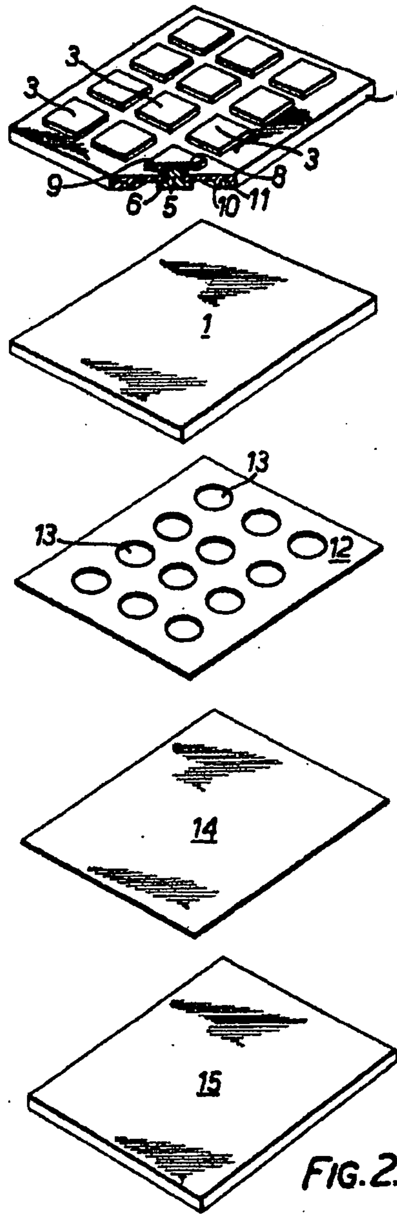

FIG. 2.

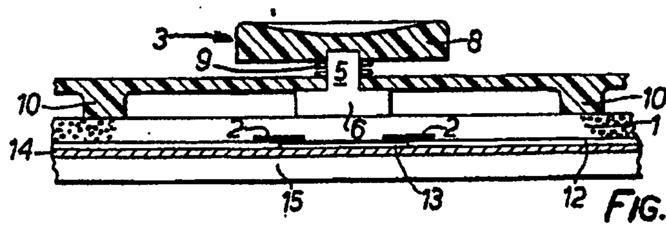

FIG.3.

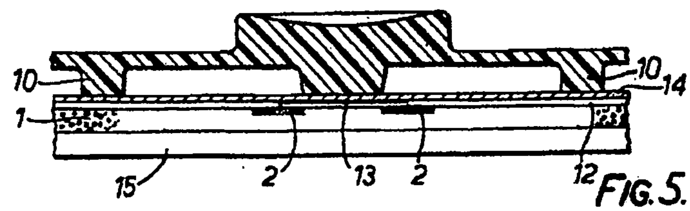

FIG.5.

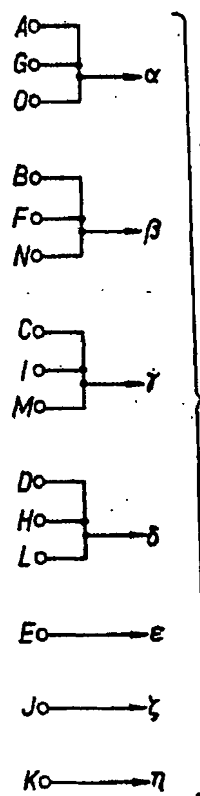

FIG.8.

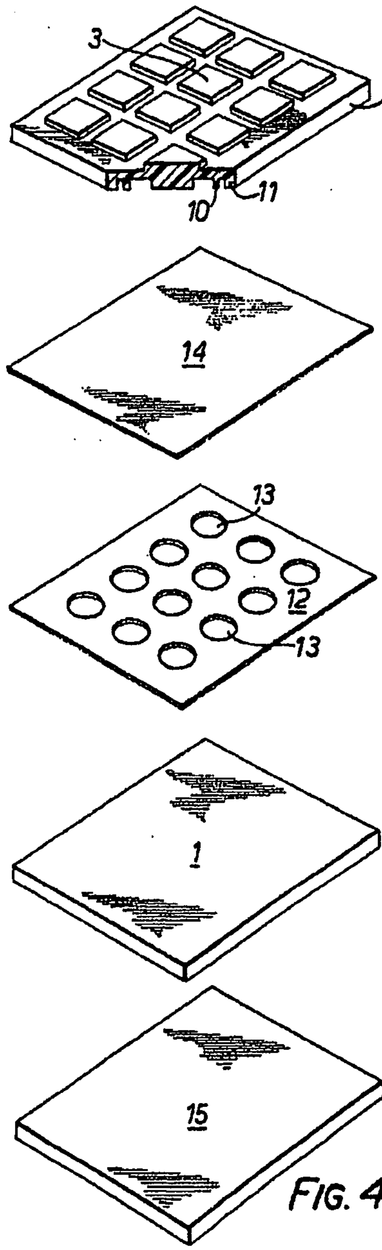

FIG. 4.

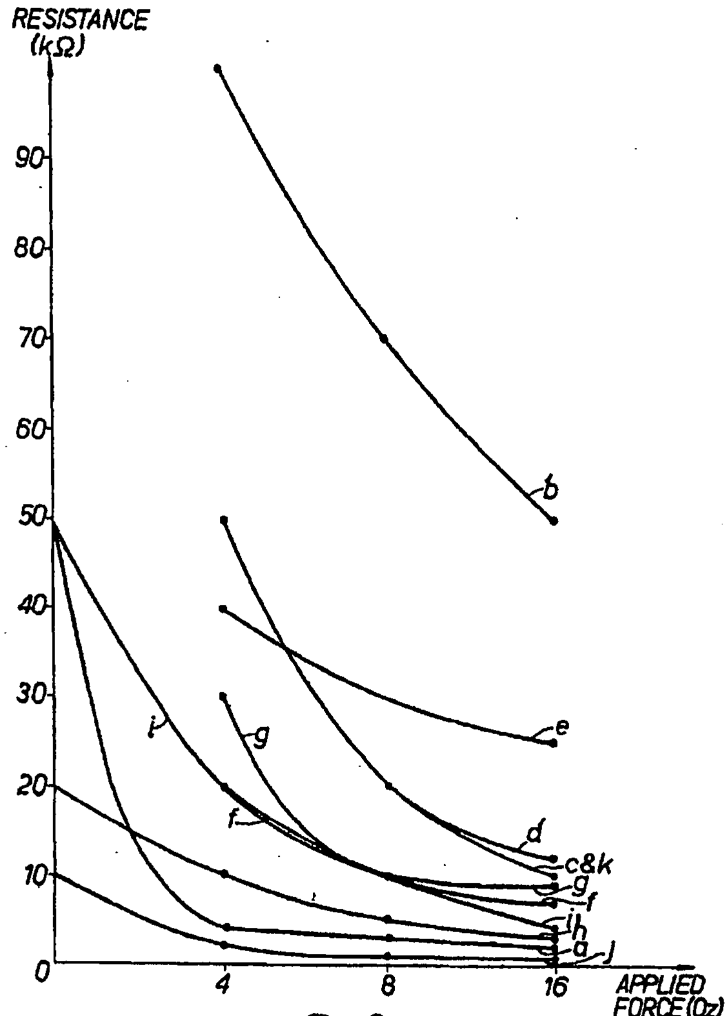
RESISTANCE (kΩ)
90
80
70
60
50
40
30
20
10
0
4
8
16
APPLIED FORCE (Oz)
b
e
d
c&k
g
f
i
h
a
j

FIG. 9A.

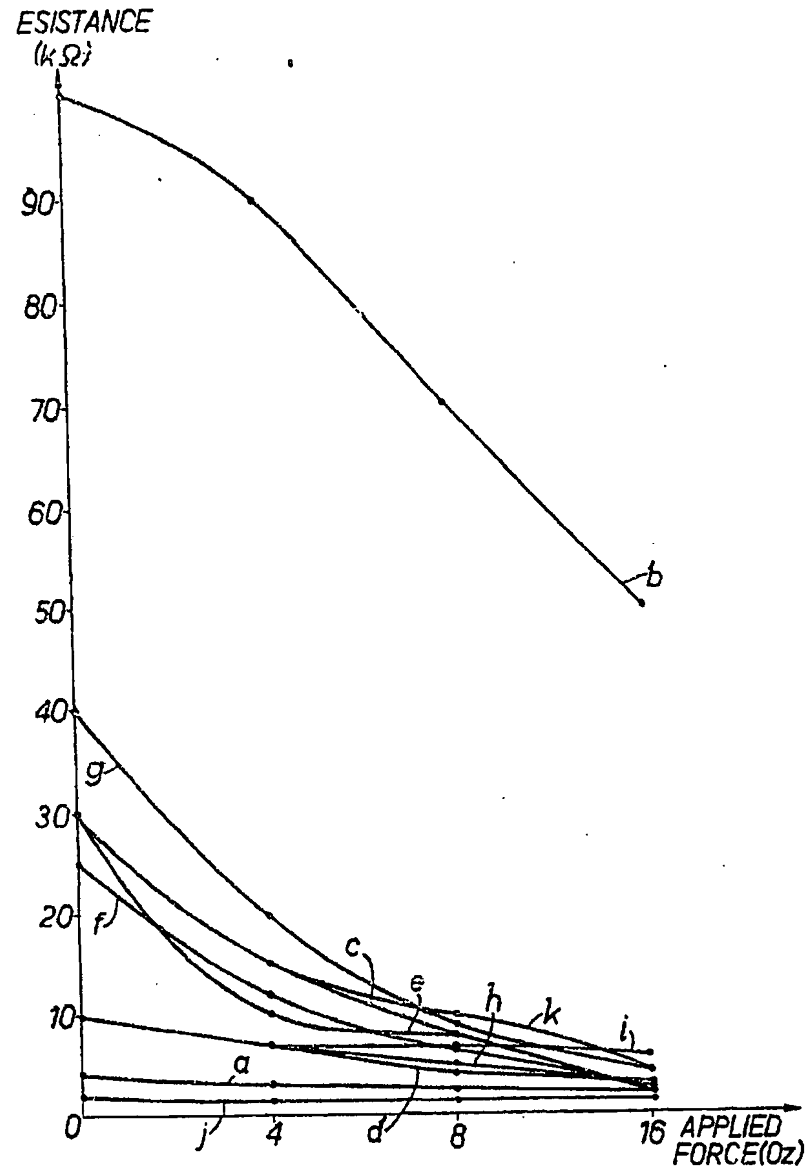
ESISTANCE
(kΩ)
90
80
70
60
50
40
30
20
10
0
4
8
16
APPLIED
FORCE(Oz)
a
b
c
d
e
f
g
h
i
j
k

FIG. 9B.